

ProtoDUNE - lesson learned

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LBNF Cryostat, final design review
SURF, 21-22 August 2017

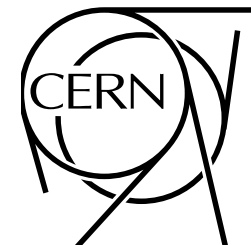


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Who Am I and Where Have I Been?

Chief Project Engineer of the CERN Neutrino Platform.
Member of the LBNF/DUNE Collaboration.

Mechanical Engineer at the ATLAS LHC project at CERN during construction and operation.

Experience includes 17 years as a project engineer for support structures for large scale physics detectors, from its conceptual stage to the final commissioning.

Large experience on design, manufacturing, underground installation, assembly and logistics.

Education as Mechanical Engineer (PhD).

A naïve statistic

ProtoDUNEs

- Boxes of insulation 432
 - IPE V 600 325T
 - IPE O 270 85T
 - Plates 80T
 - SS Plate 110T
- Total: **600T**

Bolts

- M36 6'000
 - M20 6'000
- Total: **15T**

LBNF (per cryostat)

- Boxes of insulation 4'000
- HL1100M (4km) 1'730T
- Plate (4'700m²) 450T
- Bolts (22'000 x M48) 125T

Material Procurement

- **IPE V 600 - S460ML**

- 142 x 12m (1'752m) – 325T

- **IPE O 270**

- 168 x 12m (2'016m) – 85T

- **Plates - S460ML**

- 15mm – 17x1'500x3'000mm – 10T
- 20mm – 8x1'500mmx3'000mm – 6T
- 30mm – 42x2'000mmx3'000mm – 60T

- **Plates – 304L**

- 10mm – 250 x 3'200mm x 1'600mm – 110T

- **Bolts:**

- M36x120 (10.9) – 6'000pcs
- M20x70 (10.9) – 6'000pcs
- Plus all the washers (24'000) and the nuts (12'000)



An example how:

- 400T of profiles
- 110T of SS plates
- 15T of bolts, nuts and washers

Looks like



Warm Vessel – Production

June – November 2016

- *The contract was awarded in April 2016*
- *Material delivered to the company May 2016*
- *Production – started in June with first pieces arriving in August 2016*
- *Initially in one company, but later we used also another one to speed up the production of the second cryostat*



ENH1 – Layout

August

- *The building was handed to the collaboration on August 2016*
- *It was not entirely ready. For example the lights needed to be installed in parallel to our activities.*
- *The first activity was to measure the pit and mark the exact position of the cryostats*



First Truck arriving

13th of August

- *As soon as the pieces were ready in the company we shipped them to CERN*
- *The arrival of the first truck (the floor)*



Floor preparation

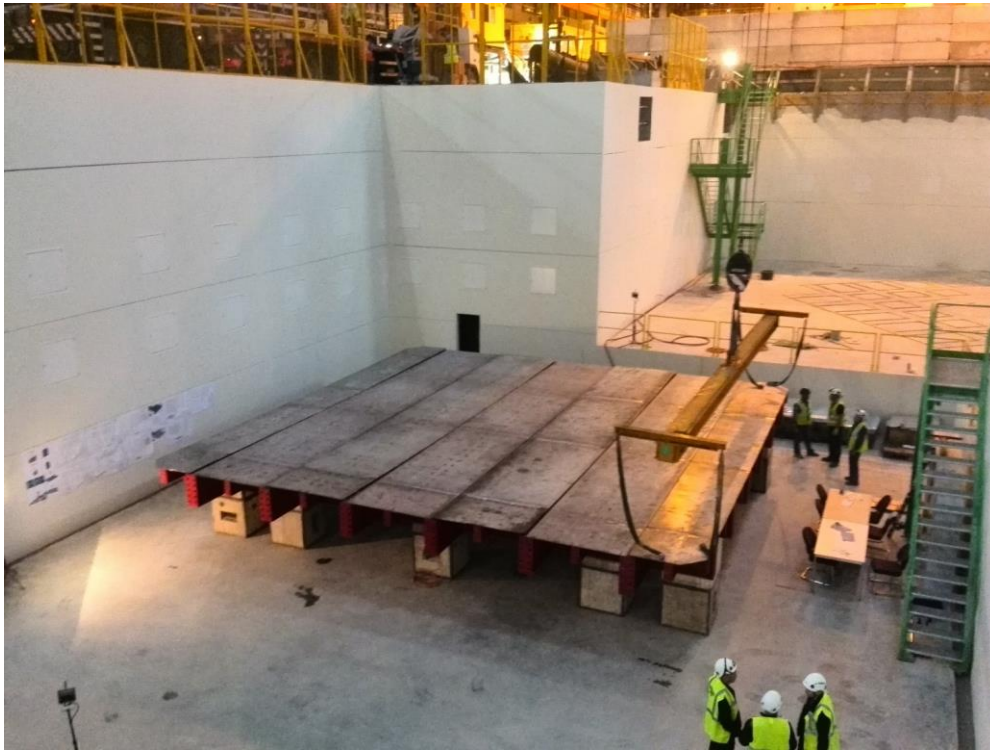
18th of August

- *The floor was measured and found to be out of specification*
- *As mitigation, an additional leveling concrete was casted*
- *A possible solution for LBNF*

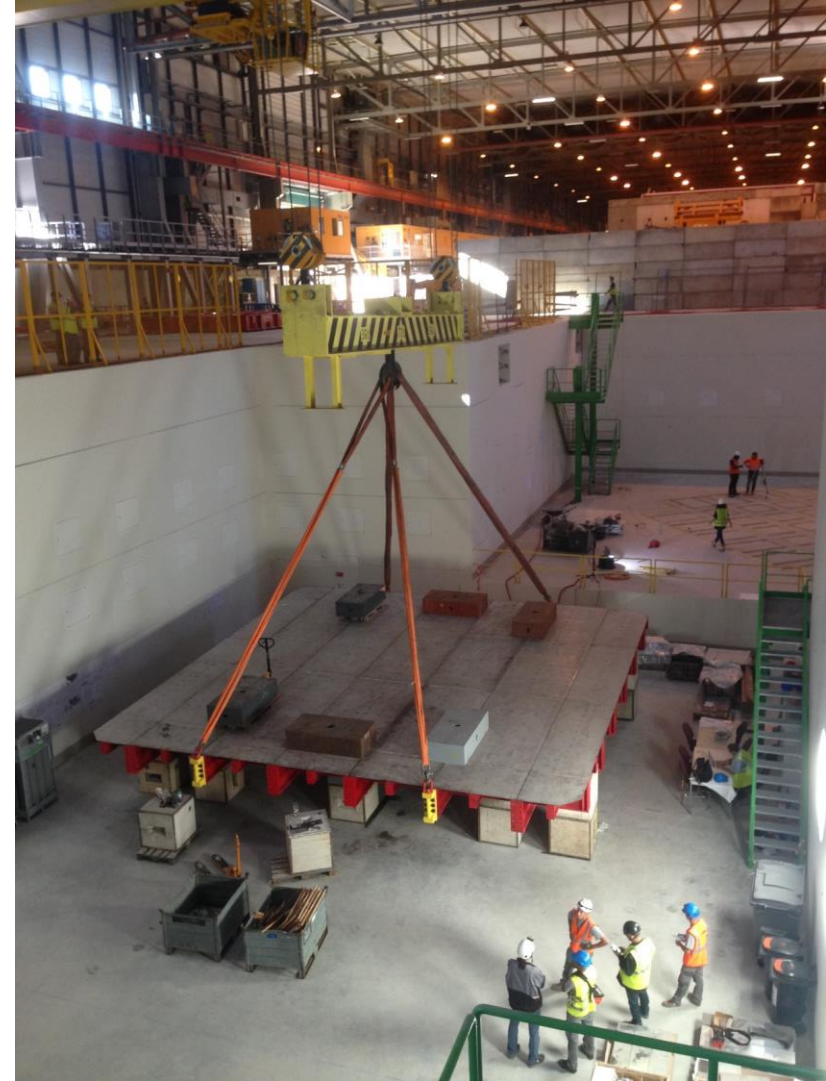


The Cryostat Floor

7th of September



- *Assembly of the cryostat floor
Including 70m of dual-pass weld*



Installation of the supporting elastomer

14th of September



Floor positioning

19th of September

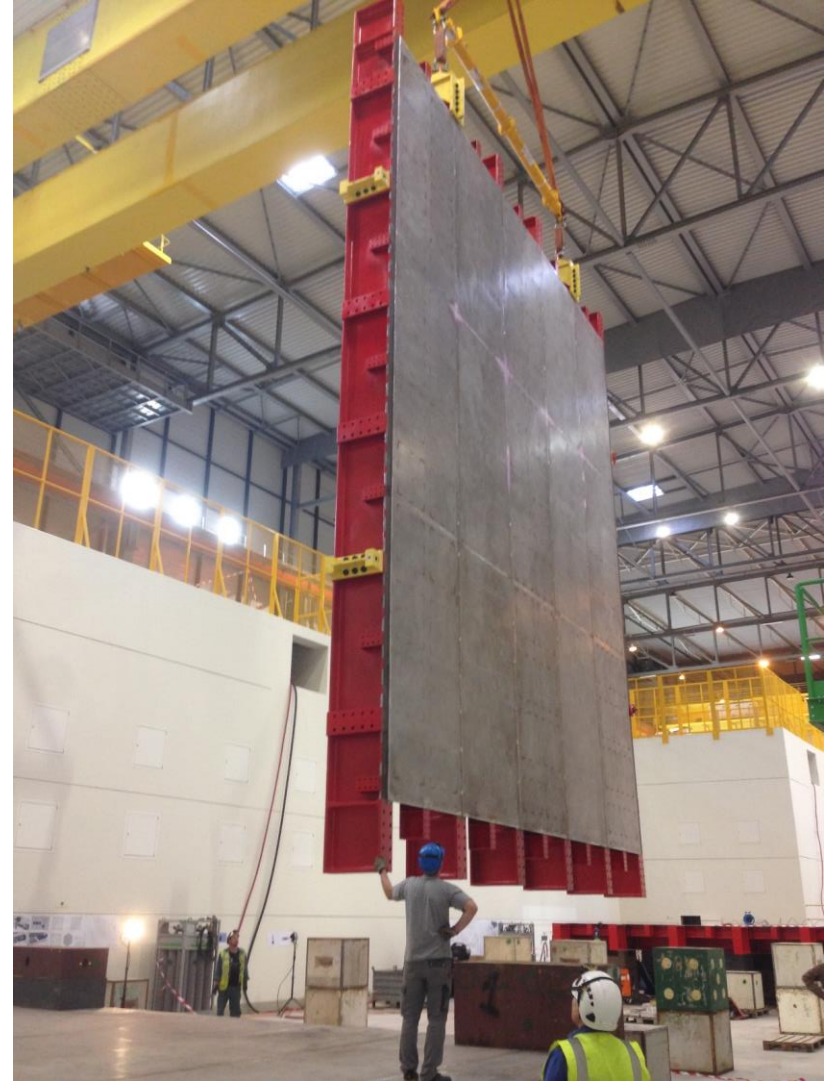


- *The floor moved to its final position (40T)*

First Wall installation

27th of September

- *The first wall assembled, welded and put in position*



First Corner installation

24th of October

- *The first corner put in position*



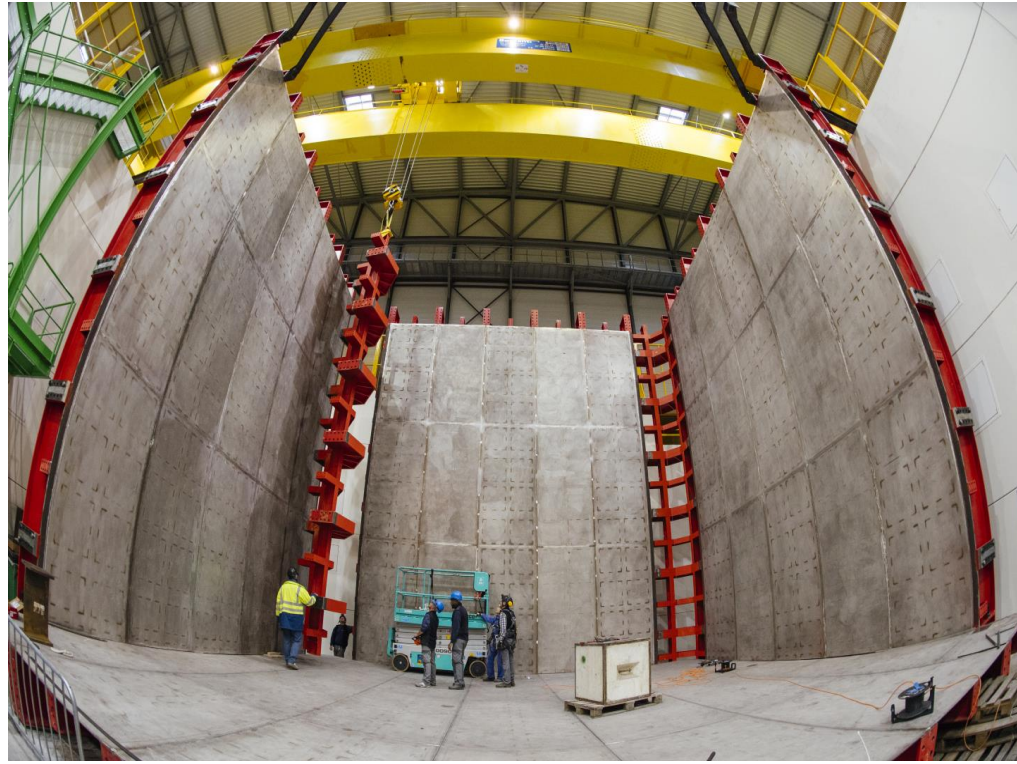
Second Corner installation

10th of November

- The second corner put in position*



Work was performed in parallel at several assembly stations



Last Wall assembly

11th of November

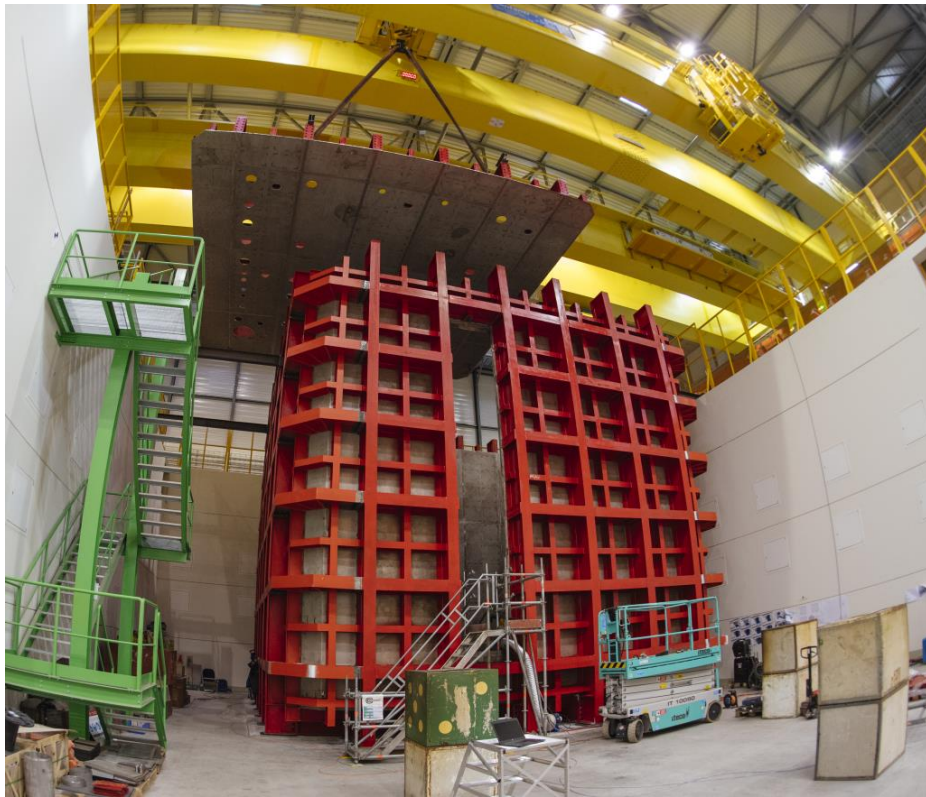
- *The opening of the TCO*

- *The hydraulic wrench used*



The Roof installation

2nd of December

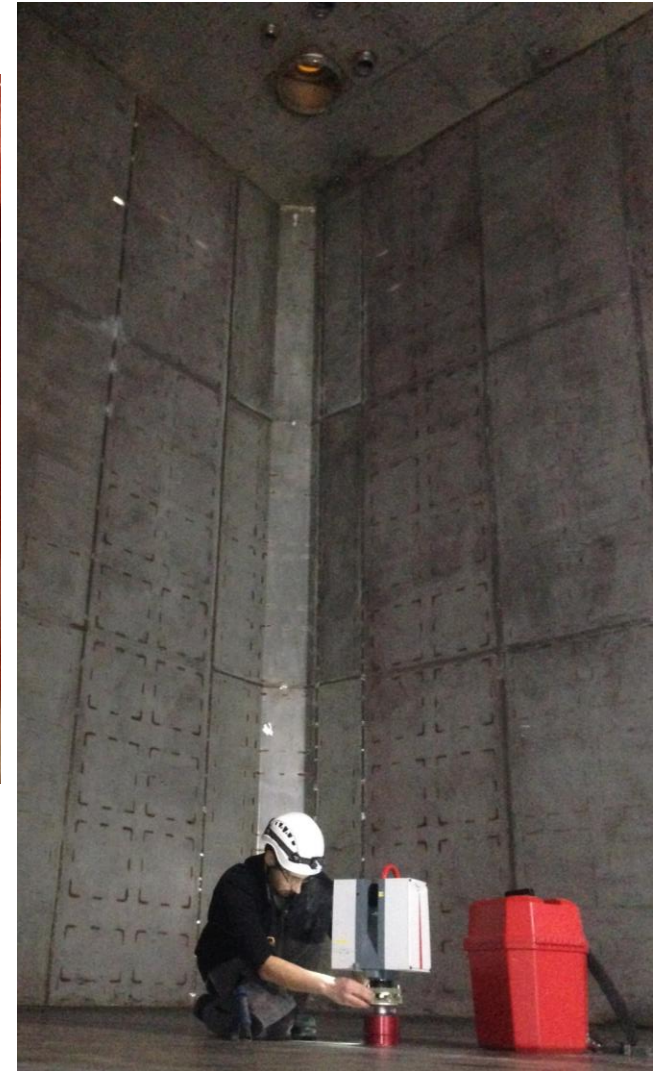


Note that the pieces for NP02 are already in the hall

Internal Welding

EHN1 – He leak test & 3D Scan

5th of January



- To close the structure, more than 250m of dual-pass welding was done in couple of weeks inside the cryostat*

Penetrations and crossing pipes



- 53 penetrations for NP04
- 77 penetrations for NP02
- All pipes checked for verticality

Lesson learnt from the small prototype



Gabadi & GTT

- *In mid December, also 27 maritime (40') containers containing 432 boxes with insulation were received and stocked inside the building*



Insulation installation



- *On 9th of January GABADI (the installation company) & GTT (the licensing company) arrived and started the installation of the insulation*

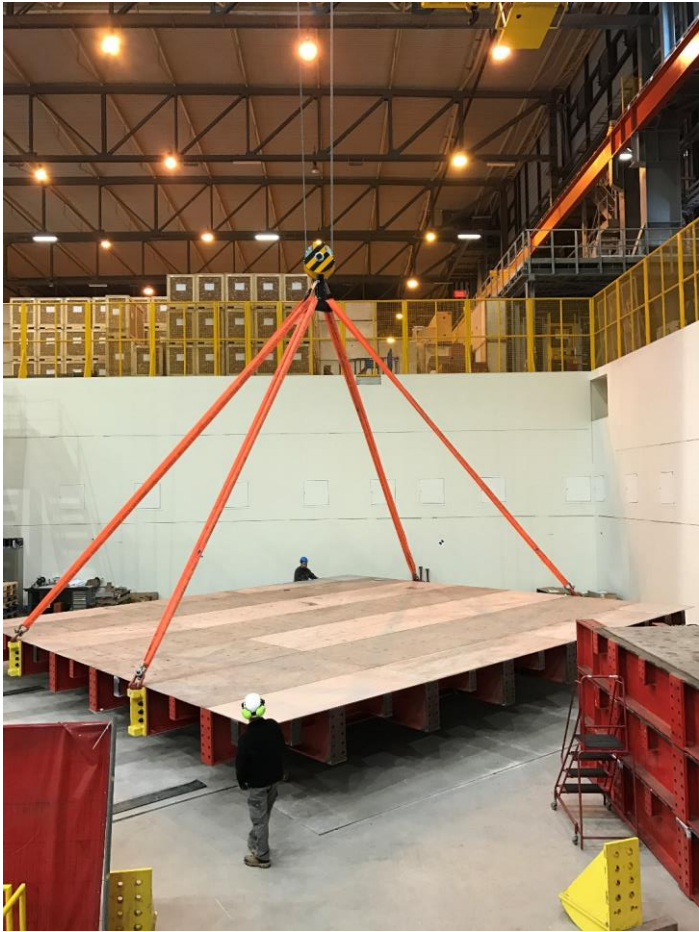


NP02 – Start of the Cryostat assembly

January'17

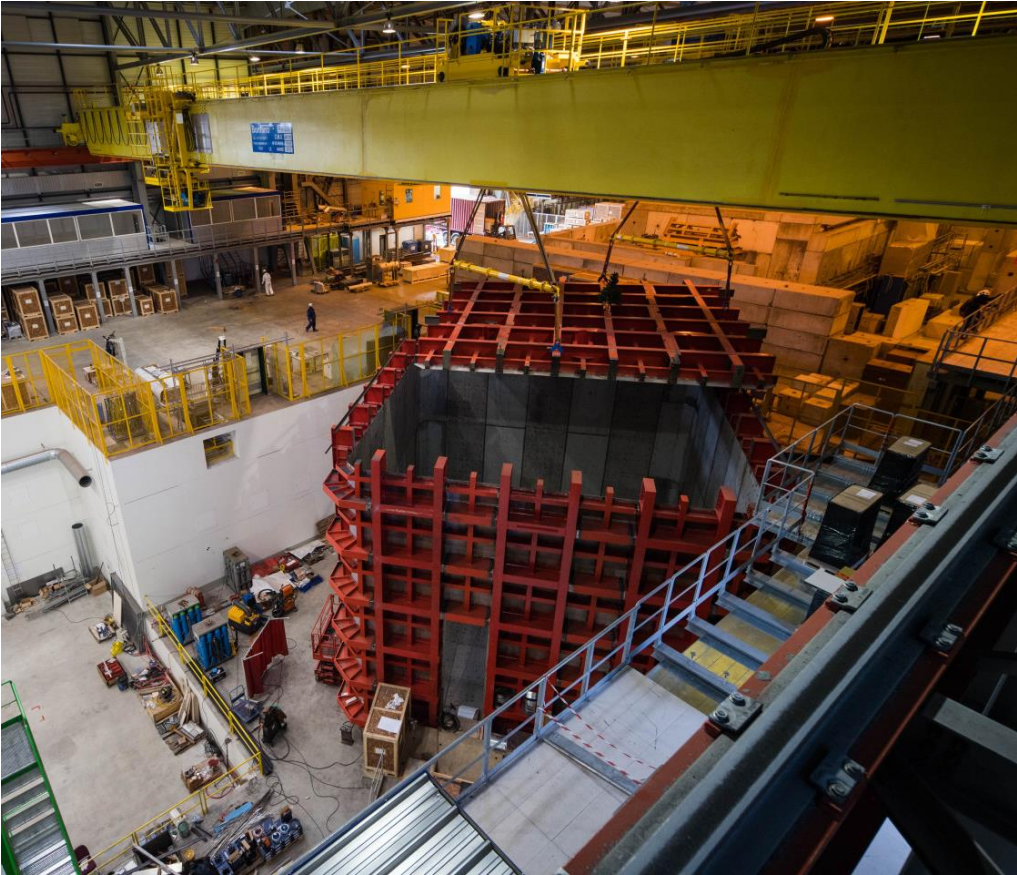


In mean time we started assembling the NP02



NP02 – The end of the Cryostat assembly

March'17



Installation of the roof for NP02



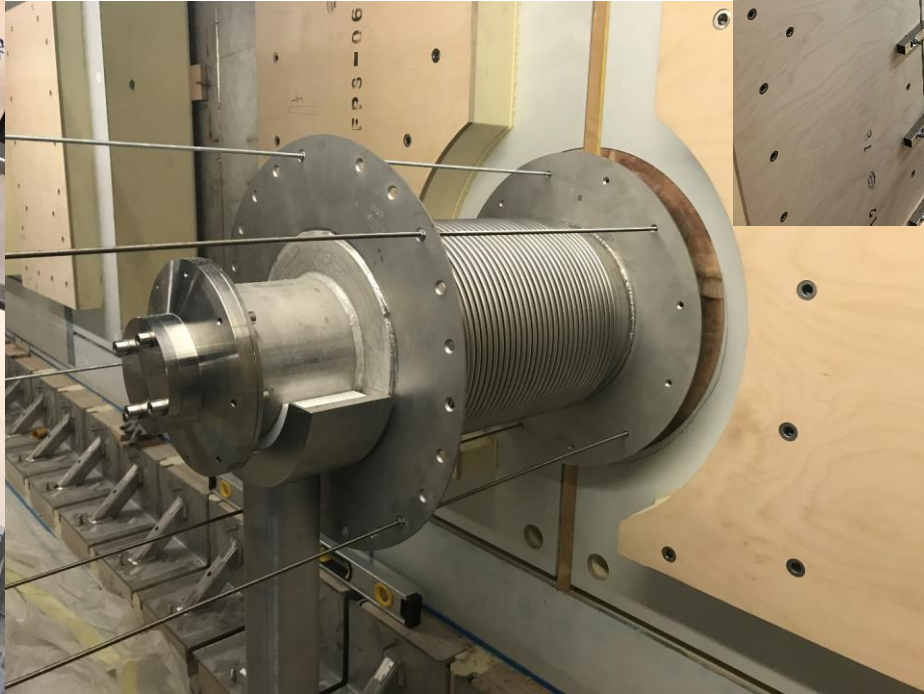
NP02/04 – Insulation installation



NP02/04 – Insulation installation



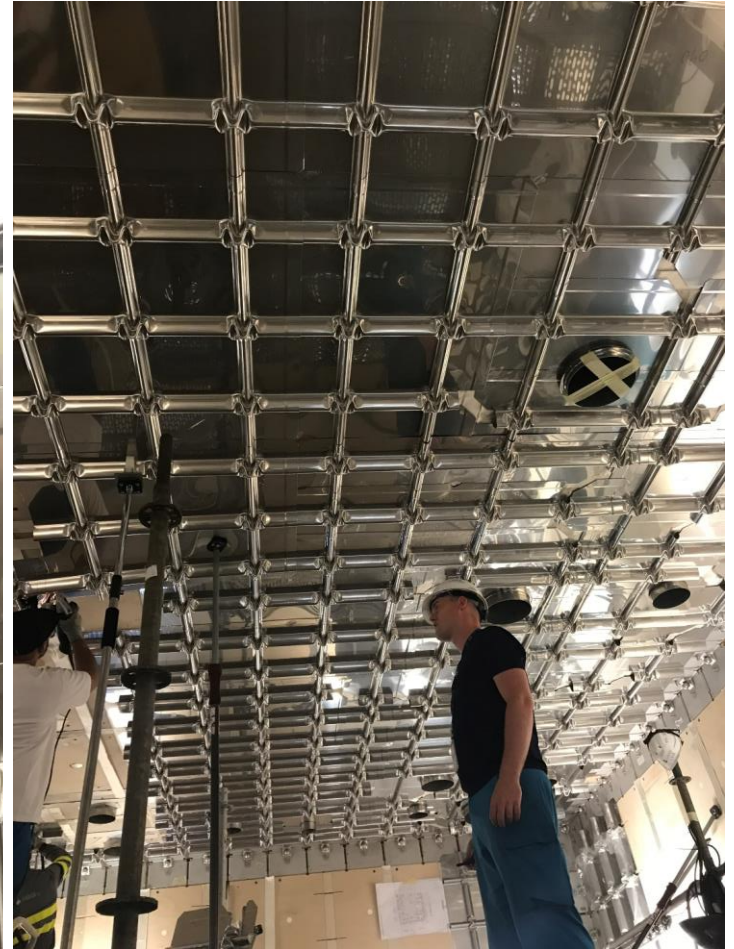
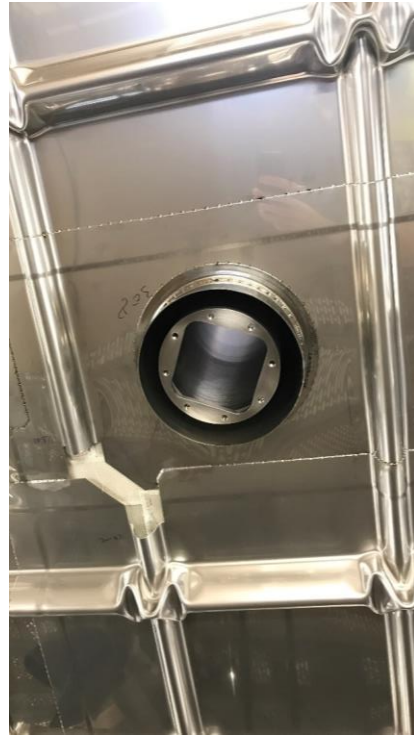
The installation of the Protego valve



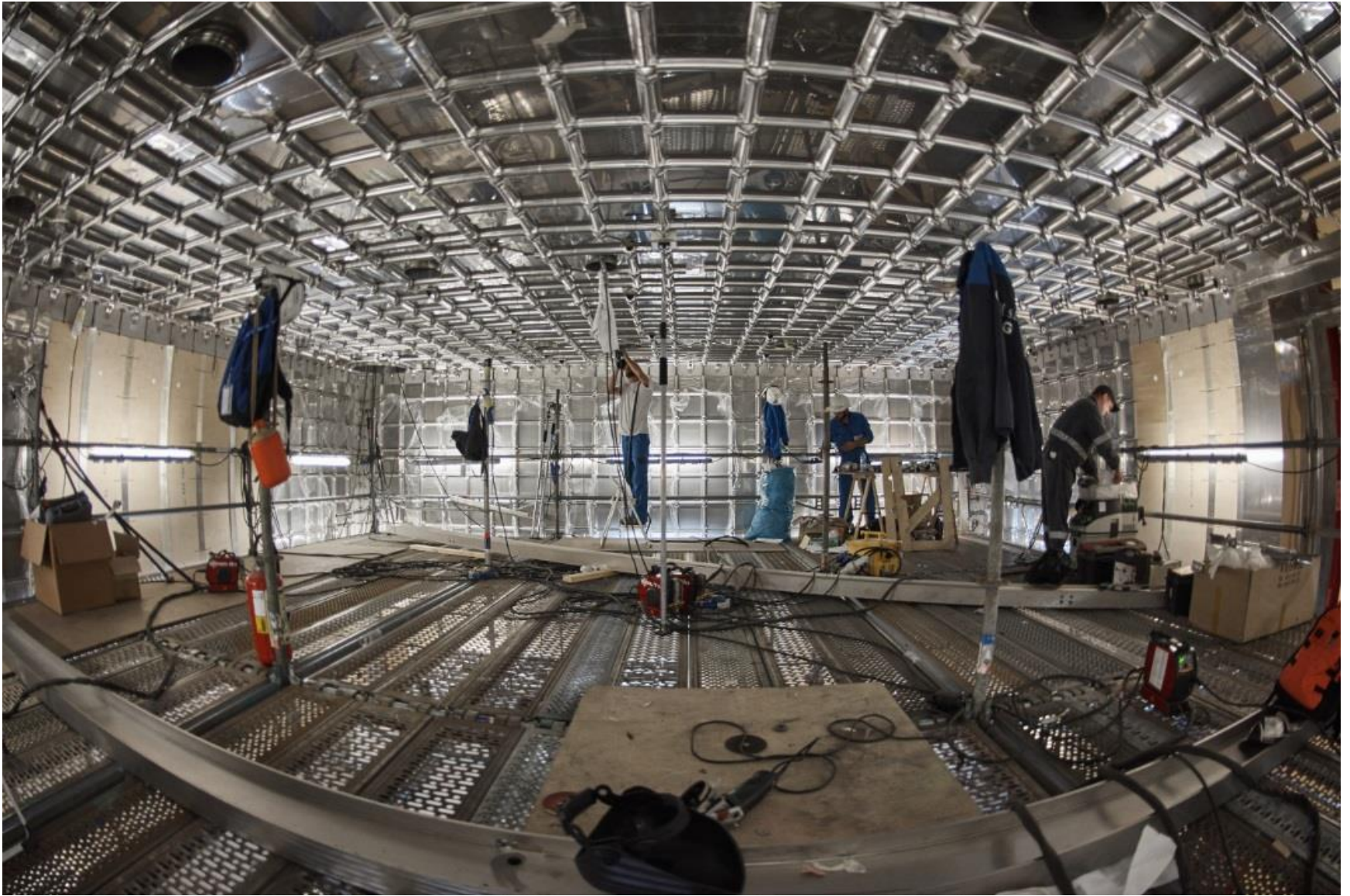
NP02/04 – Membrane installation



DSS installation



NP02/04 – Membrane installation



NP02/04 – Membrane installation



Documents and references

- EHN1-warm cryostat functional specification
EDMS: <https://edms.cern.ch/document/1531438/3>
- EHN1-warm cryostat current drawings
EDMS: <https://edms.cern.ch/document/1531439/2>
- EHN1-cold cryostat requirements
EDMS: <https://edms.cern.ch/document/1543254/4>

Summary

- We tried to use protoDUNEs as prototypes for everything
From the steel structure design and material,
throughout the welding parameters and consumables
to the insulation thickness and assembly methods
 - 5 months to construct the first one
 - less than 3 for the second
- No major surprises, but the lesson was learnt!
Some examples:
 - Small profiles (less than HEB600) don't exist in S460ML
 - Welding the outer plate before the entire structure is assembled, brings additional deformations, which makes the assembly longer.
 - Transporting from the supplier the bolts shall be dealt with more attention
 - The flatness of the floor is very important (shimming when no visibility shall be avoided)
 - Parallelising activities has limits